

Von Bertalanffy Growth Model Fitting - No Sex Term

Alex Benecke

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```
LMBL <- read.csv("Data/Clean-Data/2016_largemouth-bass_long-format.csv") %>%
  select(FID:BI.len) %>%
  arrange(FID, Agei)
```

```
### Making factors factors
LMBL$FID <- factor(LMBL$FID)
LMBL$Site <- factor(LMBL$Site)
LMBL$SEXCON <- factor(LMBL$SEXCON)
LMBL$Sex <- factor(LMBL$Sex)
```

```
str(LMBL)
```

```
## 'data.frame': 337 obs. of 11 variables:
## $ FID : Factor w/ 126 levels "1","2","3","4",...: 1 1 1 1 2 2 2 2 3 3 ...
## $ Site : Factor w/ 11 levels "2","4","6","8",...: 6 6 6 6 6 6 6 6 6 6 ...
## $ AgeCap: int 4 4 4 4 4 4 4 4 4 4 ...
## $ RadCap: num 0.94 0.94 0.94 0.94 0.988 ...
## $ LenCap: int 347 347 347 347 292 292 292 292 348 348 ...
## $ WTg : int 658 658 658 658 415 415 415 415 557 557 ...
## $ SEXCON: Factor w/ 5 levels "0","1","3","6",...: 5 5 5 5 3 3 3 3 3 3 ...
## $ Sex : Factor w/ 3 levels "0","1","2": 3 3 3 3 2 2 2 2 2 2 ...
## $ Agei : int 1 2 3 4 1 2 3 4 1 2 ...
## $ Radi : num 0.433 0.69 0.803 0.927 0.567 ...
## $ BI.len: num 155 252 295 342 165 ...
```

```
headtail(LMBL)
```

```
##      FID Site AgeCap RadCap LenCap WTg SEXCON Sex Agei Radi BI.len
## 1      1  11      4 0.9402   347 658      8  2    1 0.4328 154.6790
## 2      1  11      4 0.9402   347 658      8  2    2 0.6898 252.0903
## 3      1  11      4 0.9402   347 658      8  2    3 0.8028 294.9210
## 335 132 15972      7 1.0474   395 971      3  1    5 0.9567 359.9617
## 336 132 15972      7 1.0474   395 971      3  1    6 1.0119 381.2860
## 337 132 15972      7 1.0474   395 971      3  1    7 1.0365 390.7892
```

```
datgr = groupedData(BI.len ~ Agei | FID, data = LMBL,
  labels = list(x = "Age", y = "Size"),
  units = list(x = "(Years)", y = "(mm)"))
```

Creating the von Bertalanffy function.

```
LVB <- function(x, Linf, K, t0){
  y = Linf * (1 - exp(-K * (x - t0)))
  y
}
LVB <- vbFuns()

LVB(5, 422.8, 0.39, -0.40)
```

```
## [1] 371.3351
```

```
LVB(5, Linf = c(422.8, 0.39, -0.40)) ### Should be the same output
```

```
## [1] 371.3351
```

VBGM Fit via NLME to Both Sexes, {nlme.mod}

```
nlme.mod <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,  
  fixed = list(Linf ~ 1, K ~ 1, t0 ~ 1),  
  random = Linf+K+t0 ~ 1,  
  start = list(fixed =  
    c(Linf = 389.3647,  
      K = 0.4359,  
      t0 = -0.3127)),  
  method= "REML",  
  control=list(opt="nlminb",  
    maxIter=100,  
    pnlsMaxIter=100,  
    msMaxIter=100,  
    niterEM=100))  
  
#save(nlme.mod,  
#  file = "model-output/nlme.mod.rda")  
  
## [1] "Iterations = 4"  
  
## Nonlinear mixed-effects model fit by REML  
## Model: BI.len ~ LVB(Agei, Linf, K, t0)  
## Data: datgr  
##      AIC      BIC    logLik  
## 2833.928 2872.039 -1406.964  
##  
## Random effects:  
## Formula: list(Linf ~ 1, K ~ 1, t0 ~ 1)  
## Level: FID  
## Structure: General positive-definite, Log-Cholesky parametrization  
##      StdDev      Corr  
## Linf  60.8327092 Linf    K  
## K      0.1289488 -0.873  
## t0     0.4352377 -0.670  0.856  
## Residual 4.7627527  
##  
## Fixed effects: list(Linf ~ 1, K ~ 1, t0 ~ 1)  
##      Value Std.Error DF t-value p-value  
## Linf 425.6965  7.665872 209 55.53139      0  
## K      0.4009  0.015719 209 25.50485      0  
## t0    -0.3666  0.043430 209 -8.44185      0  
## Correlation:  
##      Linf    K  
## K    -0.884  
## t0   -0.609  0.804  
##  
## Standardized Within-Group Residuals:  
##      Min      Q1      Med      Q3      Max  
## -2.0847753 -0.1981814  0.0278886  0.4229808  3.2823985
```

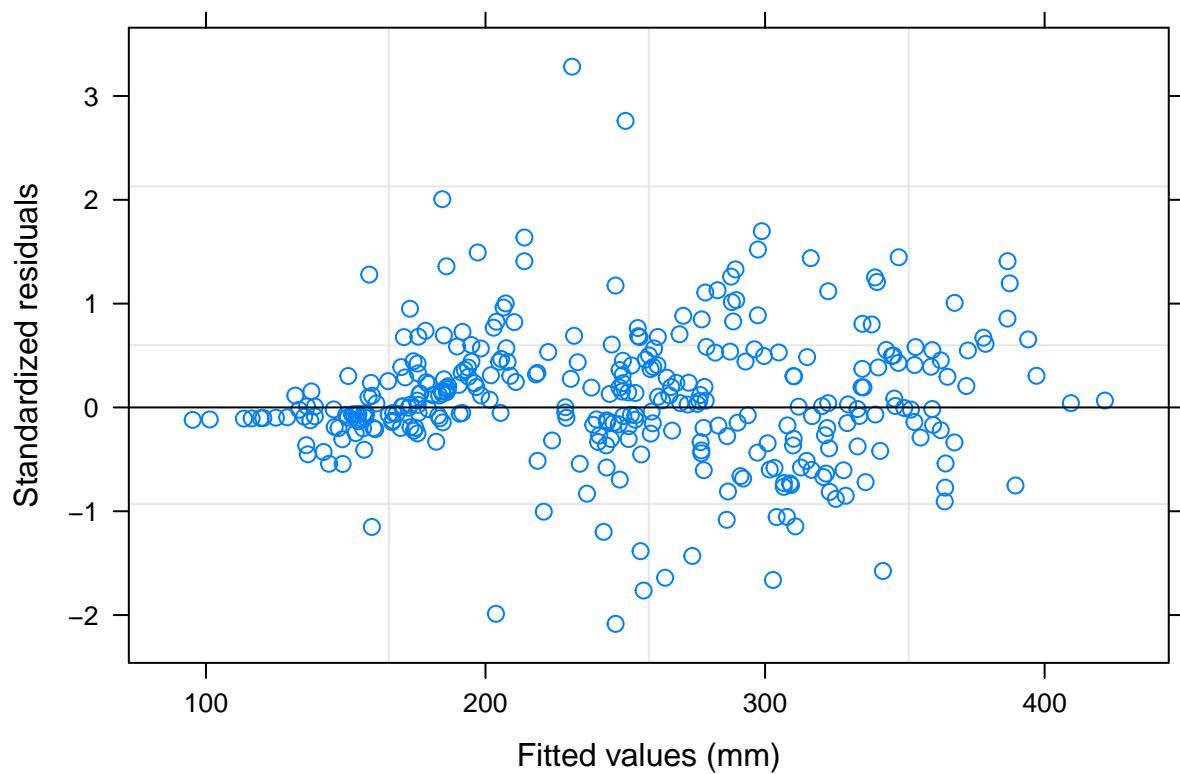
```

##
## Number of Observations: 337
## Number of Groups: 126

## Approximate 95% confidence intervals
##
## Fixed effects:
##      lower      est.      upper
## Linf 410.5841783 425.6965204 440.8088624
## K      0.3699297  0.4009183  0.4319070
## t0     -0.4522482 -0.3666309 -0.2810135
## attr("label")
## [1] "Fixed effects:"
##
## Random Effects:
## Level: FID
##      lower      est.      upper
## sd(Linf)  47.75866119 60.8327092 77.4858093
## sd(K)      0.09216863 0.1289488  0.1804062
## sd(t0)     0.36935346 0.4352377  0.5128741
## cor(Linf,K) -0.93279735 -0.8731908 -0.7670862
## cor(Linf,t0) -0.81409867 -0.6699900 -0.4481523
## cor(K,t0)    0.75059662 0.8559247  0.9188331
##
## Within-group standard error:
##      lower      est.      upper
## 4.015377 4.762753 5.649237

##      numDF denDF F-value p-value
## Linf      1   209 39477.28 <.0001
## K          1   209 2945.99 <.0001
## t0         1   209   71.26 <.0001

```



```
fixef(nlme.mod)
```

```
##          Linf          K          t0
## 425.6965204  0.4009183 -0.3666309
```

```
ranef(nlme.mod)
```

```
##          Linf          K          t0
## 88  -93.7655080  0.254102333  0.850327251
## 87  -89.5309586  0.241018178  0.807633915
## 85  -80.2756842  0.213040893  0.717194451
## 86  -78.0302853  0.206370369  0.695787193
## 83  -75.3219004  0.198380479  0.670217061
## 27  -74.4837813  0.195920011  0.662357689
## 89  -70.5055240  0.184315577  0.625378025
## 69  -66.7437139  0.173450991  0.590875294
## 84  -60.7334347  0.156297618  0.536593022
## 82  -56.7359272  0.145020539  0.501000964
## 110 -43.7085356  0.108951631  0.387272004
## 76  -40.9992916  0.101578141  0.363955618
## 80  -40.2353417  0.099507050  0.357396318
## 74  -39.0369131  0.096265119  0.347117958
## 78  -38.2839127  0.094232701  0.340666810
## 77  -37.9900873  0.093440611  0.338150867
## 75  -35.4334599  0.086571503  0.316286181
## 72  -34.1825761  0.083226102  0.305602753
## 121 -34.1367211  0.083103665  0.305211262
## 73  -10.2531257  0.022104939  0.098367680
## 7   -5.1373475  0.010435941  0.050915992
## 70   5.4358424 -0.009054611 -0.058044561
```

```

## 35    5.4592382 -0.009087252 -0.058306379
## 122    6.9699866 -0.011073280 -0.075396289
## 96     7.5302443 -0.011747867 -0.081819863
## 16    12.3531788 -0.016174613 -0.138395152
## 39    14.1472228 -0.017237878 -0.159646049
## 104   83.1805110 -0.226345819 -0.421180510
## 29    16.5716994 -0.018262076 -0.188133723
## 71    76.1181072 -0.217421642 -0.502318020
## 15    20.4980390 -0.019143259 -0.233057683
## 34    22.2430684 -0.019305381 -0.252387533
## 119   68.5556673 -0.189287798 -0.261228152
## 65   -87.3945906  0.159934847  0.434778395
## 91   -71.8797729  0.164307295  0.529623403
## 63   -72.5208369  0.157019130  0.493945783
## 107   50.9380516 -0.170610018 -0.559899453
## 64   -40.6743335  0.042804181  0.161924862
## 67   -44.5197633  0.061143030  0.206853864
## 58    40.5098677 -0.145836216 -0.526376796
## 120   38.8853475 -0.135024683 -0.420431485
## 111   13.3701851 -0.070680594 -0.082612646
## 66    35.2282493 -0.123895270 -0.368067142
## 131  -39.9027149  0.107761773  0.392898942
## 68    17.5988554 -0.078215182 -0.138379185
## 106  -32.8342277  0.098353224  0.369698476
## 130  -30.9233230  0.087232442  0.328753142
## 98   -31.5441222  0.122549806  0.471819735
## 56   -30.4175534  0.098318308  0.373911453
## 62    16.2260378 -0.070960912 -0.180191484
## 112  -12.1176351  0.009225910  0.074871498
## 126    3.7573486 -0.034119839 -0.066668531
## 53    -4.9322721 -0.008237626  0.016178226
## 115  -19.5897005  0.055708011  0.221511133
## 117   13.7330580 -0.053081267 -0.205915325
## 33     6.0197569 -0.026408005 -0.085735797
## 99   -15.1967909  0.090824135  0.362590935
## 108  -11.5832215  0.066657109  0.265891961
## 127  -13.0763895  0.090891072  0.364520334
## 95     6.4447668 -0.014588334 -0.063531173
## 57    17.9159489 -0.060167949 -0.331951918
## 102    1.7147396  0.020904280  0.075744444
## 100    8.9650067 -0.014620009 -0.080450062
## 8     15.7849615 -0.035082721 -0.212953075
## 125    4.6771434  0.067692615  0.268132168
## 123   15.9741933 -0.018372610 -0.144805850
## 14    20.4862748 -0.045252794 -0.338809870
## 23    21.9593209 -0.047771744 -0.393442937
## 54    16.3288729  0.049478834  0.174557258
## 52   -73.3878437  0.167216683  0.497155460
## 2     46.2684987 -0.225471248 -0.964255731
## 97    18.8247175  0.081900056  0.325276646
## 18   -60.6897244  0.065822138  0.075977175
## 92    24.2833476  0.061999373  0.225010550
## 19    30.5406512 -0.017638826 -0.245465882
## 114   30.2783334  0.013437375 -0.045038926

```

```
## 101 30.5900672 0.054245365 0.177186538
## 25 32.0130709 0.004888832 -0.102958124
## 45 32.7407168 0.055482821 0.180262579
## 43 -24.1980353 0.001771404 -0.070703355
## 36 -41.2370782 0.071076175 0.069316779
## 90 41.4174993 0.022939601 -0.022754211
## 46 32.1206158 -0.045481794 -0.608836678
## 61 12.0809816 -0.081178442 -0.435853646
## 17 -17.1189292 0.009467309 -0.098306636
## 118 24.1400040 -0.070149278 -0.174038710
## 60 -37.5590692 0.010448970 0.085143563
## 113 -57.4836597 0.105911110 0.232544310
## 47 36.6778559 -0.194094834 -0.512475080
## 103 85.0945465 -0.184806818 -0.253603681
## 30 21.6241329 -0.113606416 -0.274434821
## 94 13.0463836 -0.109045286 -0.510903418
## 50 7.6772732 -0.160758874 -0.754503398
## 32 18.8423544 -0.011500207 -0.219451161
## 129 -31.3895085 0.048286533 0.141988495
## 51 -26.2563435 -0.085581390 -0.408891614
## 31 48.4141916 -0.129249249 -0.266371420
## 3 -28.8049055 0.042189431 -0.064866856
## 1 -28.2235852 0.066161338 0.294133556
## 109 -22.1428517 -0.033826426 0.184543733
## 21 -16.9999997 0.027025016 -0.021977793
## 59 -30.1476525 -0.035440764 -0.279231852
## 116 -34.0509764 0.016645187 0.222360867
## 48 6.3788969 -0.022631486 0.048965519
## 38 -12.9872176 -0.017337489 -0.537493698
## 93 -10.8413781 0.046596875 0.142831978
## 41 75.8494011 -0.150791340 -0.361141014
## 20 47.9671915 -0.123178187 -0.572165599
## 105 7.5355958 -0.062207231 -0.643223351
## 5 49.5248474 -0.081452492 -0.063056461
## 4 36.8841703 -0.173255202 -0.442855846
## 128 78.1186269 -0.174222121 -0.143621610
## 42 -0.2860772 0.024116903 -0.143235143
## 49 71.1358837 -0.233586456 -0.542669407
## 44 32.5580286 -0.067297659 -0.243573735
## 22 8.2148233 0.031849559 0.106664425
## 13 70.3178106 -0.178991963 -0.730004858
## 12 0.8241870 -0.018052706 -0.006550835
## 9 39.5732351 -0.046386743 -0.183247825
## 40 68.1604558 -0.076820382 -0.130041373
## 26 45.1782200 -0.162970172 -0.015381762
## 132 -24.6260301 0.069678281 0.290659452
## 37 89.1641423 -0.163747006 -0.523779348
## 11 52.8137176 -0.025319517 -0.252902255
## 10 113.7101496 -0.240192906 -0.486463371
## 24 56.8967254 -0.063958567 0.229931178
```

```
coef(nlme.mod)[1,3]
```

```
## [1] 0.4836964
```

```

Axes <- seq(100,450,by=50)
Years <- seq(0,10,by=1)

## plot individual fish data
## plot the fixed parameter model
## plot individual fish models

plot(jitter(LMBL$Agei),LMBL$BI.len,
     col=rgb(0,1,0,0.25, maxColorValue=1),
     pch=19,
     ylim=c(100,475),
     xlim=c(0,10),
     xlab = "Age (Years)",
     ylab = "Back-Calculated Length (mm)",
     bty="n",
     yaxt="n",
     xaxt="n")

axis(2,at = Axes)
axis(1,at = Years)

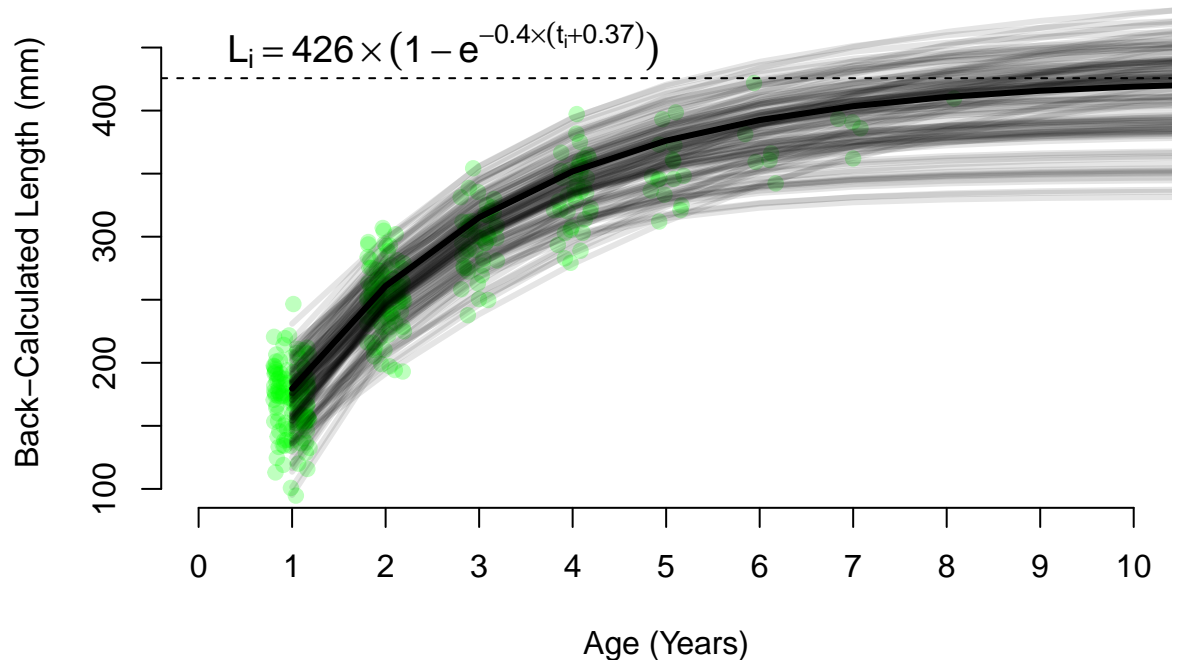
abline(h=425.6965204,lty=2)

x <- seq(1,11,by=1)
lines(x, fixef(nlme.mod)[1] * (1 - exp(-fixef(nlme.mod)[2] * (x - (fixef(nlme.mod)[3])))),
      lwd=3,
      col="black")

for(i in 1:126){
  lines(x, coef(nlme.mod)[i,1] * (1 - exp(- coef(nlme.mod)[i,2]
* (x - ( coef(nlme.mod)[i,3] )))),lwd=3,col=gray(0,0.1)) }

legend("topleft",
      legend = print(expression(L[i]==426 %*% (1 - e **{-0.40 %*% (t[i] + 0.37)}))),
      bty="n",
      cex=1.15)

```



```
## expression(L[i] == 426 %*% (1 - e^{
##   -0.4 %*% (t[i] + 0.37)
## }))
```

Modeling Fixed Effects for Sex

Lets look at the von Bertalanffy growth model fits with a fixed sex term on the parameter estimates.

In order to fit the sex model I will have to remove the individual with no sex. In order to compare the sex model to the no sex model I will have to re fit the no sex model without the individual with unknown sex. this means making new df excluding this individual. making a new grouped data object. and rerunning the nlme function.

Removing the individual with no sex (FID=89??)

```
### Just looking at data
head(LMBL)
```

##	FID	Site	AgeCap	RadCap	LenCap	WTg	SEXCON	Sex	Agei	Radi	BI.len
## 1	1	11	4	0.9402	347	658	8	2	1	0.4328	154.6790
## 2	1	11	4	0.9402	347	658	8	2	2	0.6898	252.0903
## 3	1	11	4	0.9402	347	658	8	2	3	0.8028	294.9210
## 4	1	11	4	0.9402	347	658	8	2	4	0.9269	341.9589
## 5	2	11	4	0.9884	292	415	3	1	1	0.5665	164.5096
## 6	2	11	4	0.9884	292	415	3	1	2	0.7181	210.3203

```
### Finding fish with unknown sex
(unknown.sex <- filterD(LMBL, Sex==0))
```

##	FID	Site	AgeCap	RadCap	LenCap	WTg	SEXCON	Sex	Agei	Radi	BI.len
## 1	89	8	1	0.4328	136	38	0	0	1	0.3983	124.5434


```

### Getting row number for fish with the unknown sex
(FID89 <- as.numeric(row.names(LMBL[LMBL$Sex==0,])))

## [1] 230

### removing the fish with unknown sex from the data set
length(LMBL$FID) ### just seeing the number of rows in the data set

## [1] 337

length(unique(LMBL$FID)) ### just seeing the number of fish

## [1] 126

LMBL <- LMBL[-c(FID89),]
length(LMBL$FID)

## [1] 336

length(unique(LMBL$FID)) ### Good! looks like only FID 89 was removed

## [1] 125

### Lets make sure there is no empty row in my data
LMBL <- filterD(LMBL,!is.na(FID))
### and lets just take a quick look at the data
str(LMBL)

## 'data.frame': 336 obs. of 11 variables:
## $ FID : Factor w/ 125 levels "1","2","3","4",...: 1 1 1 1 2 2 2 2 3 3 ...
## $ Site : Factor w/ 11 levels "2","4","6","8",...: 6 6 6 6 6 6 6 6 6 6 ...
## $ AgeCap: int 4 4 4 4 4 4 4 4 4 4 ...
## $ RadCap: num 0.94 0.94 0.94 0.94 0.988 ...
## $ LenCap: int 347 347 347 347 292 292 292 292 348 348 ...
## $ WTg : int 658 658 658 658 415 415 415 415 557 557 ...
## $ SEXCON: Factor w/ 4 levels "1","3","6","8": 4 4 4 4 2 2 2 2 2 2 ...
## $ Sex : Factor w/ 2 levels "1","2": 2 2 2 2 1 1 1 1 1 1 ...
## $ Agei : int 1 2 3 4 1 2 3 4 1 2 ...
## $ Radi : num 0.433 0.69 0.803 0.927 0.567 ...
## $ BI.len: num 155 252 295 342 165 ...

headtail(LMBL)

## FID Site AgeCap RadCap LenCap WTg SEXCON Sex Agei Radi BI.len
## 1 1 11 4 0.9402 347 658 8 2 1 0.4328 154.6790
## 2 1 11 4 0.9402 347 658 8 2 2 0.6898 252.0903
## 3 1 11 4 0.9402 347 658 8 2 3 0.8028 294.9210
## 334 132 15972 7 1.0474 395 971 3 1 5 0.9567 359.9617
## 335 132 15972 7 1.0474 395 971 3 1 6 1.0119 381.2860
## 336 132 15972 7 1.0474 395 971 3 1 7 1.0365 390.7892

```

Remake Grouped Data Object

```

datgr = groupedData(BI.len ~ Agei|FID, data = LMBL,
                    labels = list(x = "Age", y = "Size"),
                    units = list(x = "(Years)", y = "(mm)"))

```

Re-Fitting VBGM Without Sex Terms After Removing Unkown Sex Fish

```
nlme.mod2 <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,
  fixed = list(Linf ~ 1, K ~ 1, t0 ~ 1),
  random = Linf+K+t0 ~ 1,
  start = list(fixed =
    c(Linf = 389.3647,
      K = 0.4359,
      t0 = -0.3127)),
  method= "REML",
  control=list(opt="nllminb",
    maxIter=100,
    pnlsMaxIter=100,
    msMaxIter=100,
    niterEM=100))

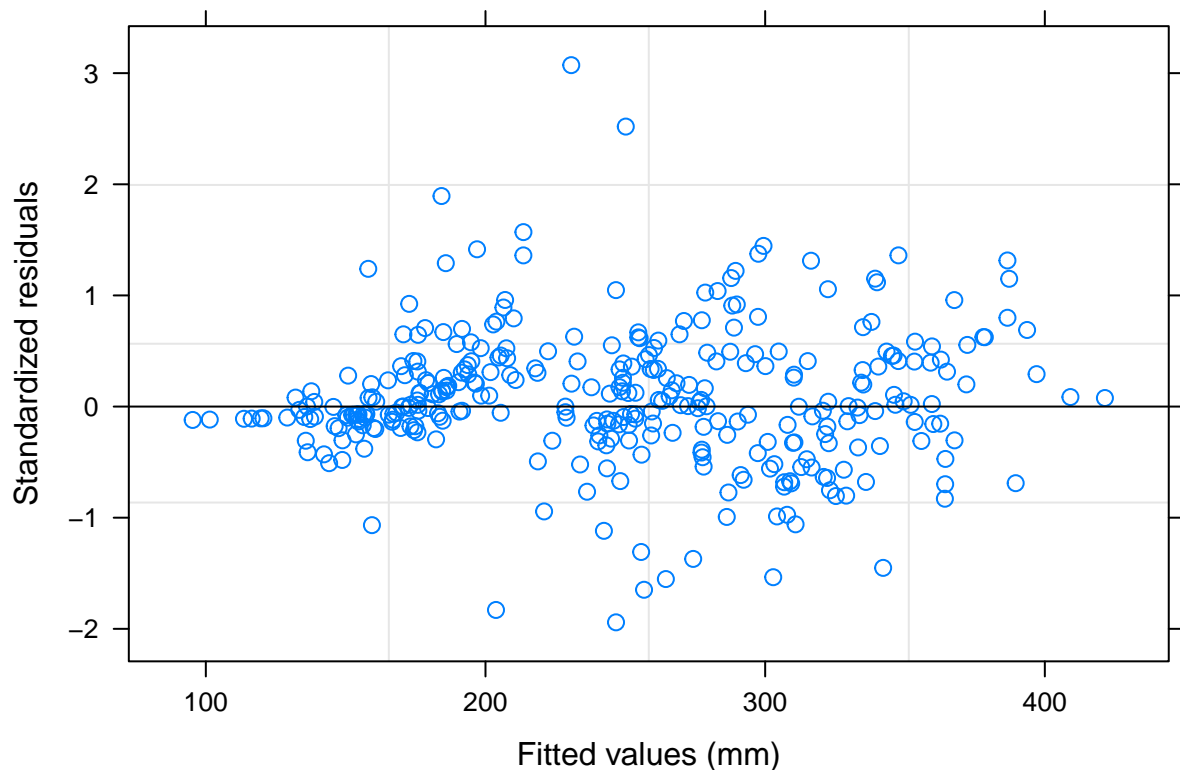
#save(nlme.mod2,
#  file = "model-output/nlme.mod2.rda")
```

```
## [1] "Iterations = 8"

## Nonlinear mixed-effects model fit by REML
## Model: BI.len ~ LVB(Agei, Linf, K, t0)
## Data: datgr
##      AIC      BIC    logLik
## 2825.199 2863.28 -1402.599
##
## Random effects:
## Formula: list(Linf ~ 1, K ~ 1, t0 ~ 1)
## Level: FID
## Structure: General positive-definite, Log-Cholesky parametrization
##      StdDev      Corr
## Linf  60.2706899 Linf   K
## K      0.1636979 -0.896
## t0      0.4051268 -0.743  0.880
## Residual 5.1861779
##
## Fixed effects: list(Linf ~ 1, K ~ 1, t0 ~ 1)
##      Value Std.Error DF t-value p-value
## Linf 422.1732  7.758468 209 54.41450    0
## K      0.4092  0.019320 209 21.18083    0
## t0     -0.3564  0.042235 209 -8.43892    0
## Correlation:
## Linf   K
## K    -0.897
## t0   -0.680  0.849
##
## Standardized Within-Group Residuals:
##      Min      Q1      Med      Q3      Max
## -1.94148193 -0.17864102  0.01619288  0.39153583  3.07200909
##
## Number of Observations: 336
## Number of Groups: 125

## Approximate 95% confidence intervals
##
## Fixed effects:
##      lower      est.      upper
```

```
## Linf 406.8783142 422.1731988 437.4680835
## K      0.3711197  0.4092061  0.4472924
## t0     -0.4396794 -0.3564181 -0.2731568
## attr("label")
## [1] "Fixed effects:"
##
## Random Effects:
## Level: FID
##
##          lower      est.      upper
## sd(Linf)  46.20689210 60.2706899 78.6150269
## sd(K)      0.07580475 0.1636979 0.3535001
## sd(t0)     0.30276138 0.4051268 0.5421027
## cor(Linf,K) -0.96608505 -0.8959355 -0.7026344
## cor(Linf,t0) -0.90420164 -0.7425586 -0.3948487
## cor(K,t0)   0.74950984 0.8803736 0.9450186
##
## Within-group standard error:
## lower      est.      upper
## 3.325330 5.186178 8.088353
##
##      numDF denDF  F-value p-value
## Linf    1    209 38273.06 <.0001
## K        1    209 2870.19 <.0001
## t0       1    209   71.22 <.0001
```



Not too different from nlme.mod as expected.

Full Sex Model, {sexmod.lkt}

Sex terms on all model parameters

```
sexmod.lkt <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,
  fixed = list(Linf ~ Sex-1, K ~ Sex-1, t0 ~ Sex-1),
  random = Linf+K+t0 ~ 1,
  start = list(fixed =
    c(Linf = c(389.3647,389.3647),
      K = c(0.4359,0.4359),
      t0 = c(-0.3127,-0.3127))),
  method= "REML",
  control=list(opt="nlminb",
    maxIter=100,
    pnlsMaxIter=100,
    msMaxIter=100,
    niterEM=100))

save(sexmod.lkt,
  file = "model-output/sexmod.lkt.rda")
```

$\{L_\infty, K\}$ Sex Model, {sexmod.lk}

```
sexmod.lk <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,
  fixed = list(Linf ~ Sex-1, K ~ Sex-1, t0 ~ 1),
  random = Linf+K+t0 ~ 1,
  start = list(fixed =
    c(Linf = c(389.3647,389.3647),
      K = c(0.4359,0.4359),
      t0 = -0.3127)),
  method= "REML",
  control=list(opt="nlminb",
    maxIter=1000000,
    pnlsMaxIter=100,
    msMaxIter=100,
    niterEM=100))

save(sexmod.lk,
  file = "model-output/sexmod.lk.rda")
```

$\{L_\infty, t_0\}$ Sex Model, {sexmod.lt}

```
sexmod.lt <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,
  fixed = list(Linf ~ Sex-1, K ~ 1, t0 ~ Sex-1),
  random = Linf+K+t0 ~ 1,
  start = list(fixed =
    c(Linf = c(389.3647,389.3647),
      K = 0.4359,
      t0 = c(-0.3127,-0.3127))),
  method= "REML",
  control=list(opt="nlminb",
    maxIter=100,
    pnlsMaxIter=100,
    msMaxIter=100,
    niterEM=100))

save(sexmod.lt,
```

```
file = "model-output/sexmod.lt.rda")
```

$\{K, t_0\}$, Sex Model, {sexmod.kt}

```
sexmod.kt <- nlme::nlme(BI.len ~ LVB(Agei, Linf, K, t0), data = datgr,
  fixed = list(Linf ~ 1, K ~ Sex-1, t0 ~ Sex-1),
  random = Linf+K+t0 ~ 1,
  start = list(fixed =
    c(Linf = 389.3647,
      K = c(0.4359, 0.4359),
      t0 = c(-0.3127, -0.3127))),
  method= "REML",
  control=list(opt="nlsminb",
    maxIter=100,
    pnlsMaxIter=100,
    msMaxIter=100,
    niterEM=100))
save(sexmod.kt,
  file = "model-output/sexmod.kt.rda")
```

Comparing Models

Summary

The von Bertalanffy growth model was fit to 337 observations of length at age from 126 individuals. Five additional individuals with out age estimates were removed from the growth analysis. The maximum asymptotic length (L_∞) fit to both male and females was estimated to be 426 mm (SE=7.7). The brody growth rate coefficient (K) was estimated as 0.40 (SE=0.02). The estimated value of t_0 is -0.37 (SE=0.04). Differences in the estimated growth parameters for different sexes were explored and found to be not significant(**Need to report statistics**).